SUISUN THISTLE MONITORING PROTOCOL FOR CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE LANDS, 2018-2023 RESULTS, AND DISCUSSION

PREPARED BY THE CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NATIVE PLANT PROGRAM

SEPTEMBER 2024

FUNDING PROVIDED BY COOPERATIVE ENDANGERED SPECIES CONSERVATION FUND GRANTS F18AP00042 AND F21AP00514 AND THE RARE AND ENDANGERED SPECIES PRESERVATION FUND

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INTRODUCTION

Suisun thistle (*Cirsium hydrophilum* var. *hydrophilum*) is a federally endangered plant that is endemic to tidal marsh habitat in Solano County, California. Suisun thistle was once described as "very common" in Suisun Bay (Greene 1892) prior to significant damage to habitats and natural processes during the 21st century. Suisun thistle now has low abundance and a very narrow distribution, and there are currently only three known populations of Suisun thistle remaining. All three populations occur entirely or partially on California Department of Fish and Wildlife (CDFW) lands (Figure 1). The Peytonia Slough population (Occurrence 1) and the Hill Slough population (Occurrence 7) are managed by CDFW, and the Rush Ranch population (Occurrence 4) is managed by the Solano Land Trust with a smaller portion managed by CDFW.

This document provides a protocol for monitoring the Suisun thistle populations on CDFW lands, summarizes 2018-2023 monitoring results, provides an interpretation of results, and provides management recommendations to facilitate adaptive management of this species. Monitoring process, results, and recommendations are critical steps in the adaptive management process.

HABITAT

Suisun thistle is restricted to well-drained tidal marsh habitat with most populations restricted to the borders of channels, creeks, and artificial ditches within tidal networks. Graham-Bruno et al. (2023) found that Suisun thistle occurs in areas where inundation time is between 6% (1.4 hours) and 24% (5.8 hours) in a 24-h period, with an average of 12.5% (3 hours). Fiedler et al. (2007) suggested that ditches created in the 1980s to reduce mosquito habitat has provided Suisun thistle with additional habitat and may have helped expand its distribution.

Suisun thistle occurs in a diverse mid-marsh vegetation zone between the low marsh, which is wetter and dominated by common tule (*Schoenoplectus acutus*), and the high marsh, which is drier and dominated by saltgrass (*Distichlis spicata*) and pickleweed (*Salicornia pacifica*)(Whitcraft et al. 2011). Suisun thistle often grows with chairmaker's bulrush (*Schoenoplectus americanus*), silverweed (*Potentilla anserina* var. *pacifica*), Baltic rush (*Juncus balticus* ssp. *ater*), gumplant (*Grindelia stricta*), and the invasive perennial pepperweed (*Lepidium latifolium*). Suisun thistle also grows with more patchily-distributed plants such as western goldenrod (*Euthamia occidentalis*), salt marsh fleabane (*Pluchea odorata*), and water groundwort (*Senecio hydrophilus*) (Whitcraft et al. 2011).

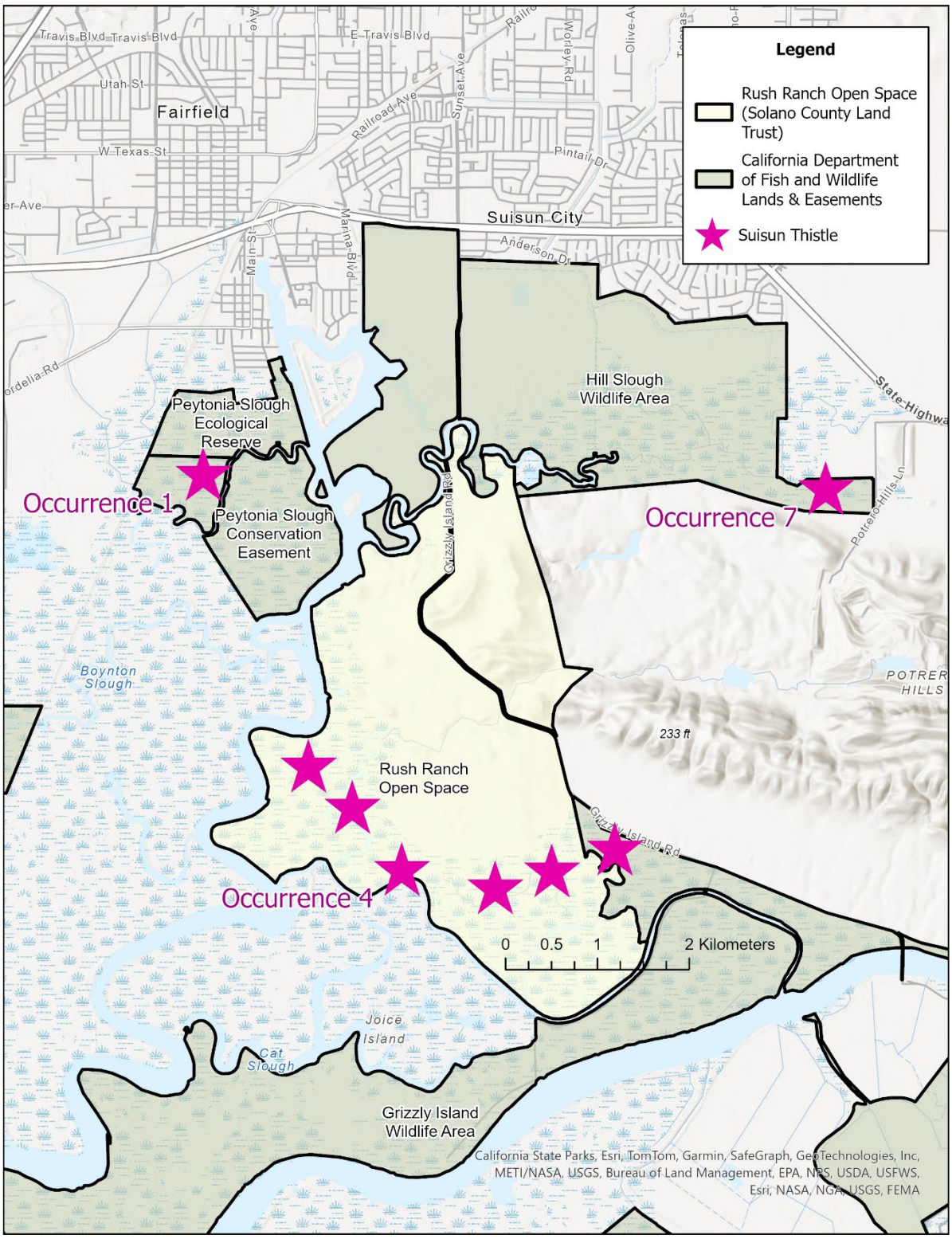

Figure 1. General locations of known Suisun thistle occurrences.

On CDFW lands, Suisun thistle has been found within several vegetation types (Geographic Information Center 2022, CNPS 2024):

- *Distichlis spicata* herbaceous alliance
    - *Distichlis spicata – Frankenia salina – Jaumea carnosa* association
    - *Distichlis spicata - Salicornia pacifica* association
    - *Distichlis spicata – Juncus arcticus* var. *balticus* (*J. mexicanus*) Coastal association
- *Schoenoplectus americanus* herbaceous alliance
    - *Schoenoplectus americanus / Lepidium latifolium* association
- *Typha* (*angustifolia, domingensis, latifolia*) herbaceous alliance

LIFE HISTORY

Suisun thistle is an herbaceous biennial or short-lived perennial plant, which means that it grows from seed and typically completes its life cycle and dies within two growing seasons. A biennial plant will germinate in growing season one and produce a large rosette of leaves. Then in growing season two, the stem elongates (i.e., bolts) and the plant produces flowers and seeds on this stem to complete its life cycle and typically dies.

In addition, field observations and laboratory experiments suggest that Suisun thistle recruitment is limited by light near channels, and by salinity away from channels, along a gradient of environmental conditions (Graham-Bruno et al. 2023). Schneider and Boyer (2021) found that Suisun thistle seeds have a relatively low average germination rate of 34% under controlled conditions. Graham-Bruno et al. (2023) treated seeds with bleach to sterilize their surface and found a similar 30% germination rate under controlled conditions. Schneider and Boyer (2021) found that Suisun thistle seeds do not germinate in salinities of more than 25 parts per thousand, and that germination increases at lower salinities. In the field, Suisun thistle seeds germinate as early as September, but these early germinating seedlings must survive low light and temperatures throughout the winter (Schneider and Boyer 2021). A high density of competing species in the surrounding plant community may inhibit Suisun thistle seedling establishment and survival. Shifts in community structure or disturbances may therefore create more openings in the vegetation and result in greater seedling establishment.

Suisun thistle blooms between June and September, but peak bloom is typically in July and August. Potential pollinators from the insect order Hymenoptera (bees, wasps, and ants) were collected from Suisun thistle inflorescences by Schneider and Boyer (2021), and included bumble bees (*Bombus vosnesenskii*), small carpenter bees (*Ceratina* sp.), chimney bees (*Diadasia bituberculata*), and mason bees (*Osmia* sp.). Suisun thistle is likely pollinated by a variety of

other insect groups as well. Suisun thistle is also able to produce seeds via self-pollination, but far fewer seeds are produced by self-pollination than through open pollination by insects (Schneider and Boyer 2021).

Suisun thistle produces relatively few seeds per inflorescence compared with other *Cirsium* species (Powell 2011, Schneider and Boyer 2021). In addition, the species experiences problems from reduced seed maturation and predation of seeds while still on the plant (Graham-Bruno et al. 2023). Schneider and Boyer (2021) found significant Suisun thistle seed predation by *Lasioderma haemorrhoidale* (Coleoptera: Ptinidae), which is a small, non-native beetle previously released as biocontrol for invasive thistles. This beetle lowered the number of seeds per capitulum (i.e., composite inflorescence consisting of many small flowers) by an average of 40%, which is a considerable impact on reproductive output. These factors all contribute to generally low seed production. Seeds appear to be dispersed by wind due to the presence of a pappus, but the pappus often detaches from the seeds and nearby vegetation is dense, resulting in short seed dispersal distances (Schneider and Boyer 2021). It is unknown how long Suisun thistle seed can remain dormant and viable in the soil seed bank.

THREATS

Primary threats to Suisun thistle include invasive plant species, animal trampling, herbivory and seed predation, habitat loss, and other disturbances.

The invasive perennial pepperweed competes with Suisun thistle for space, nutrients, and light, reduces Suisun thistle's reproductive success, and alters brackish marsh soil physicochemical characteristics to further favor perennial pepperweed (Schneider et al. 2024). For Suisun thistle populations that are adjacent to pastureland, such as at Hill Slough Wildlife Area, breaches in the fencing can result in cattle trampling and herbivory from grazing (Noss et al. 2002, Whitcraft et al. 2011, CDFW observations discussed below). Feral pigs also cause impacts in Suisun marsh and may disturb Suisun thistle habitat. Wildfire has occurred in Suisun thistle habitat in the past, burning affected wetland vegetation at CDFW's Peytonia Slough Ecological Reserve various times, including in June 2001, other times in the early 2000s, and in 2023 and in 2024. While the population of Suisun thistle did not appear to be affected in 2023 and 2024, it is unknown if the population was burned by wildfire in preceding years. Wildfire could kill Suisun thistle plants and seeds.

In addition, genetic analysis from Cantly (2023) demonstrates that Suisun thistle is highly inbred and has very low genetic diversity. Cantly (2023) estimated that the species experienced a genetic bottleneck approximately 5000 years ago, and another genetic bottleneck less than 200 years ago. The timing of these

genetic bottlenecks correlates well with the historical flooding of the Great Valley and more recent human impacts from activities such as cattle grazing and diking of wetlands. Cantly (2023) also found that the three known populations of the species represent four genetic populations. One of these genetic populations corresponds with the Hill Slough population (Occurrence 7), one corresponds with the Peytonia Slough population (Occurrence 1), and the remaining two are within the Rush Ranch population (Occurrence 4), referred to as First Mallard Branch and Second Mallard West Branch by Cantly (2023).

MONITORING LOCATION DESCRIPTIONS

Below is a description of the locations for monitoring described in this document, how they relate to the three known Suisun thistle populations, and the primary threats at each location.

Peytonia Slough Monitoring Location (Occurrence 1)

This monitoring location is at CDFW's Peytonia Slough Ecological Reserve and adjacent lands designated as Peytonia Slough Conservation Easement. This is the most difficult of the three monitoring locations to access. Suisun thistle has a patchy distribution at this location, within an area of approximately 8 hectares (20 acres). The primary threats to Suisun thistle at this location are wildfire and general threats to the species discussed above (invasive plant species and seed predation).

Joice Island Monitoring Location (Occurrence 4)

The largest population of Suisun thistle partially occurs on CDFW's Grizzly Island Wildlife Area Joice Island Unit and partially on Solano Land Trust's Rush Ranch Open Space. Within an approximately 160 hectare (400 acre) area, this population is patchily distributed. CDFW manages about 10 hectares (25 acres) of this area, and the Solano Land Trust manages the remaining area. This document describes monitoring on CDFW lands at this population, and this area is hereinafter referred to as the Joice Island Monitoring Location. The Suisun thistle plants at the Joice Island Monitoring Location are part of the Second Mallard West Branch genetic population described by Cantly (2023). The primary threats to Suisun thistle at the Joice Island Monitoring Location are the general threats to the species discussed above (invasive plant species, animal trampling (specifically pigs), herbivory, and seed predation).

Hill Slough Monitoring Location (Occurrence 7)

The Suisun thistle population at this location is within an approximately 0.8 hectare (2 acre) area, and it is mostly on CDFW's Hill Slough Wildlife Area but extends a short distance onto the neighboring property owned by the Solano

County Water Agency. The primary threat to this population is cattle trampling, herbivory and seed predation, and loss of genetic diversity from these impacts.

MONITORING PROTOCOL

This protocol should be implemented by CDFW staff to facilitate the adaptive management and persistence of Suisun thistle on CDFW lands. The protocol can be completed in two field days with two people, but more people will increase efficiency. Additional field time may be needed due to the difficulty in accessing parts of Suisun Marsh. Site visits to implement this monitoring protocol should occur from mid-July to mid-August to coincide with peak bloom for Suisun thistle, while avoiding impacts to nesting birds.

The monitoring consists of the following components:

- Monitoring known populations-
    - Mapping and counting Suisun thistle plants at all three monitoring locations.
    - Taking monitoring photographs at the Joice Island Monitoring Location.
    - Monitoring for trespass grazing at the Hill Slough Monitoring Location.
- Surveying for new populations- Surveying CDFW lands to document population extensions and/or new populations of Suisun thistle.

EQUIPMENT

- A sub-meter GPS receiver with the appropriate maps and geodatabase set up ahead of time. Make sure the Field Maps app is installed and logged into on a mobile device.
- Tally counters (two per person is ideal for counting reproductive (bolting) and non-reproductive (rosette) plants)
- Camera (dSLR or similar style) and tripod
- Compass
- Binoculars
- Kayaks, paddles, and related safety equipment (if necessary to access survey locations)
- Tide schedule
- Walking sticks for stability and to help detect obscured ditches
- Rubber boots or boots/shoes that can be worn in saltwater

PARKING AT THE SITES

Peytonia Slough Monitoring Location: There is a designated parking lot for Peytonia Slough Ecological Reserve (38.232194, -122.038222). More information is

available online at https://wildlife.ca.gov/Lands/Places-to-Visit/Peytonia-Slough-ER. The adjacent Suisun City Boat Launch facility (38.233003, -122.038272) can be used to launch kayaks for accessing remote portions of Peytonia Slough Ecological Reserve and adjacent conserved lands.

Joice Island Monitoring Location: There are parking spaces for 2-3 vehicles along Grizzly Island Road (38.197556, -122.006250) that are close to this Suisun thistle population.

Hill Slough Monitoring Location: There is parking for several vehicles at 38.222083, -121.979667, which can be reached via the access road for the Potrero Hills Landfill. Access points for surveying other portions of Hill Slough still need to be established.

Navigating to Populations

The Peytonia Slough Monitoring Location can be accessed via kayak from the Suisun City Boat Launch facility. Visits via kayak should be timed to correspond with high tide because many channels and ditches are not navigable during middle or low tides. Alternatively, a long wide wooden plank could perhaps be used as a movable bridge over narrow channels to access some areas of Peytonia Slough Ecological Reserve on foot (Figure 2).

The Joice Island Monitoring Location can be accessed on foot from the parking location, but some channels are too deep, wide, or muddy to cross, so it is not possible to fully survey this area on foot. Additional surveys should focus on accessing and surveying areas further to the southwest of the known population (Figure 3). Suisun thistle surveys in other areas of Grizzly Island Wildlife Area Joice Island Unit will likely require a motorboat, long kayak trips, and/or difficult navigation on foot.

The Hill Slough Monitoring Location can be accessed on foot from the parking location. A large channel separates the north and south portions of this population, and the two portions are accessed from the parking area via different routes. Suisun thistle surveys in other areas of Hill Slough Wildlife Area will likely require a motorboat or several long kayak trips, and/or difficult navigation on foot (Figure 4).

Keep in mind that all three locations may also have other listed and/or sensitive species present, such as soft bird's beak (*Chloropyron molle* ssp. *molle*), salt marsh harvest mouse (*Reithrodontomys raviventris*), California Ridgway's rail (*Rallus obsoletus obsoletus*), and California black rail (*Laterallus jamaicensis coturniculus*). Foot access should be kept to a minimum, and preferably after August 31st where there may be ground-nesting birds.

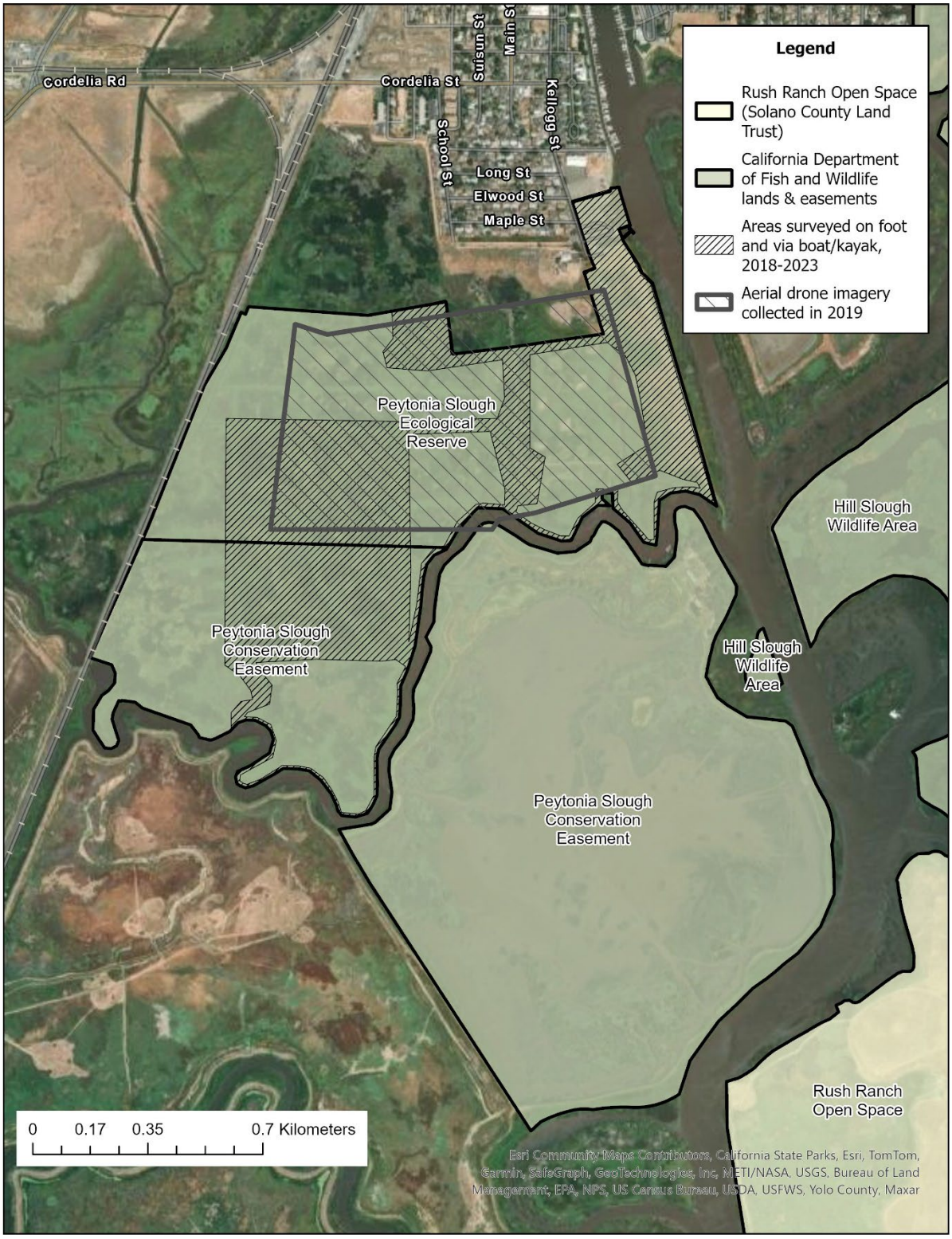

Figure 2. Areas of Peytonia Slough Ecological Reserve and Peytonia Slough Conservation Easement that were surveyed for Suisun thistle by CDFW staff

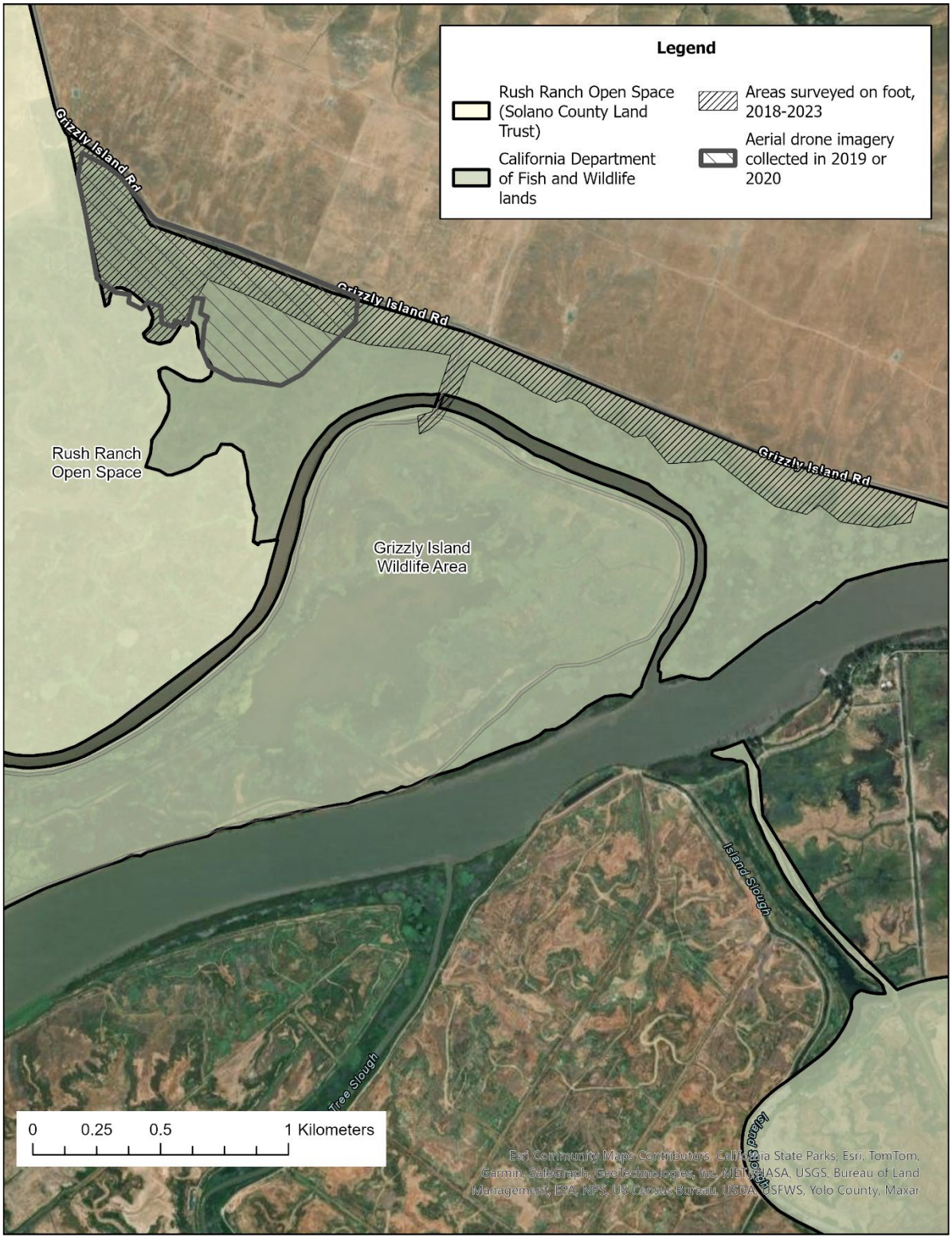

Figure 3. Areas of Grizzly Island Wildlife Area Joice Island Unit that were surveyed for Suisun thistle by CDFW staff

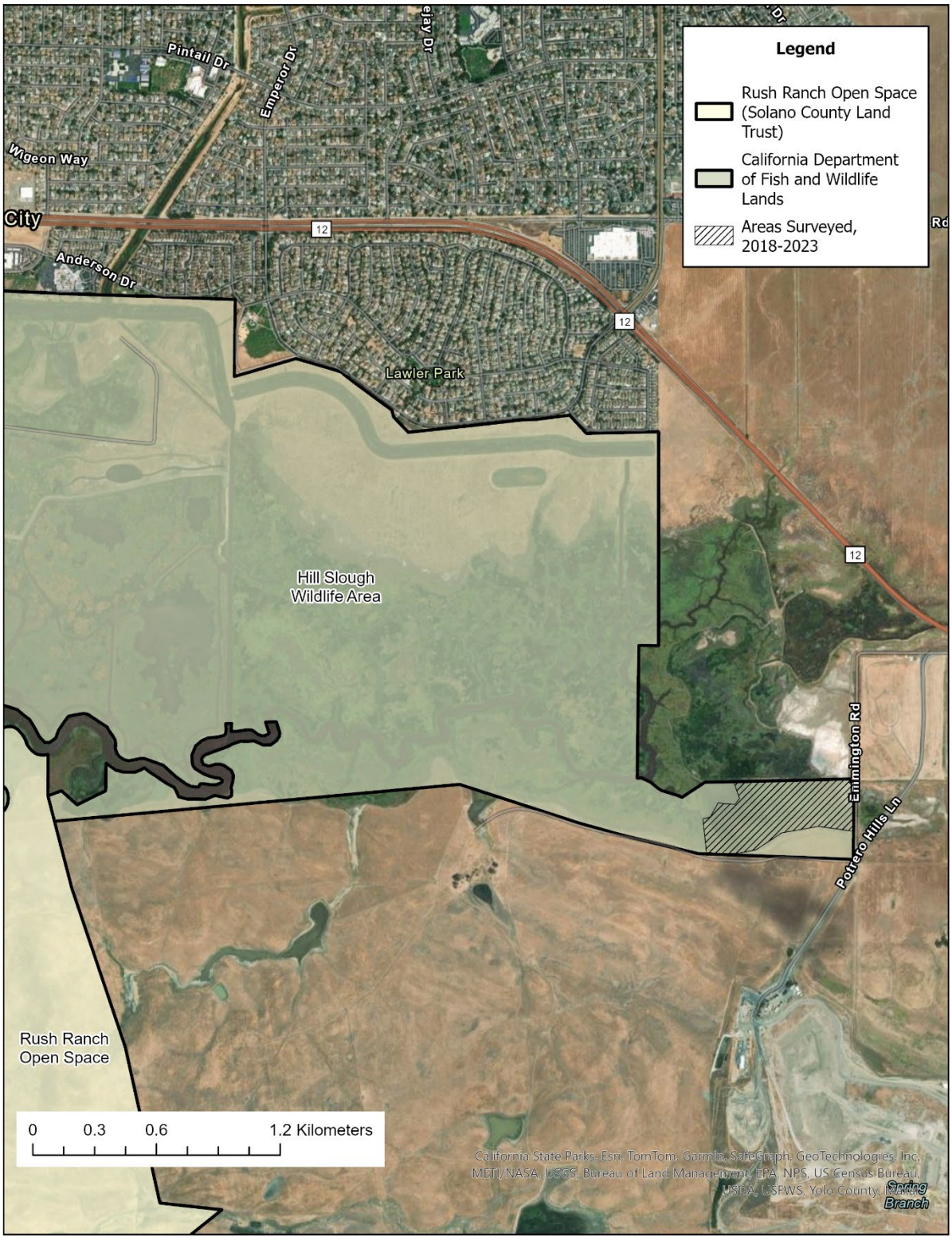

Figure 4. Areas of Hill Slough Wildlife Area that were surveyed for Suisun Thistle by CDFW staff

Frequency of Monitoring

CDFW should alternate between monitoring known populations of Suisun thistle on CDFW lands and conducting additional Suisun thistle surveys to search for the species in areas of CDFW lands yet to be surveyed, as described in Table 1. Because the Peytonia Slough Monitoring Location is difficult to access, it should be monitored opportunistically while also surveying for new populations in the area.

Table 1. Frequency of Monitoring

Monitoring Location	**Activity**	**Frequency**
All	Surveying for new populations	Even-numbered years
Joice Island	Monitoring known populations and photomonitoring.	Odd-numbered years
Hill Slough	Cattle trespass monitoring for and implementing fence repairs	Three times per year
Hill Slough	Monitoring known populations	Annually

Short compliance visits at the Hill Slough Monitoring Location should consist of regional staff stopping at the parking location (38.222083, -121.979667) and using binoculars to survey the fence for any downed posts or wire and to look for any other signs of cattle trespass onto Hill Slough Wildlife Area from the neighboring property to the north. Unpermitted cattle on CDFW lands should be reported immediately and cattle should be removed promptly.

Mapping and Counting

The primary goal of this mapping is to document changes in distribution such as groups of Suisun thistle plants found in new areas, groups of plants that are no longer present, and other changes in the size and distribution of occupied areas. Any Suisun thistle plants encountered during site visits should be mapped using a sub-meter GPS receiver with a mobile device pre-loaded with the appropriate maps and geodatabase via the ESRI Field Maps (or equivalent) application. The geodatabase for data collection should provide the ability to collect both Suisun thistle point features and polygon features, and point, line, and polygon features for "other" plants or objects. Each point feature should have a field to collect information on life history stages, a field for number of plants, and a field for notes. The field for life history stages should have the

option for the user to select from a pre-defined list (basal rosette, reproductive, or dead). Each line or polygon feature should have a field for notes.

Large continuous groups of Suisun thistle plants should be mapped with polygon features to save time. Smaller and patchier groups of Suisun thistle plants that occupy less than four square meters (43 square feet) should be mapped as point features. When collecting polygon features, the associated notes field should be used to document the number of Suisun thistle plants that are in the basal rosette life history stage, and the number of plants that are in the reproductive life history stage (e.g. bolting, flowering, fruiting). When collecting point features, the appropriate life history stage should be selected from the pre-defined list, and the number of plants in that life history stage at that point location should be recorded in the appropriate field (the "number of plants" field). So, for a small patch that contained both life stages, two points would be taken—one for the number of rosettes and one for the number of reproductive plants.

MONITORING PHOTOGRAPHS

There is one permanent monitoring photopoint at the Joice Island Monitoring Location. No other populations have a monitoring photopoint, though others could be established.

Photopoint A: An approximately 2-foot length of square aluminum conduit is hammered into the ground at 38.19752178, -122.0069631 to serve as a photomonitoring monument. The monument has an aluminum tag on it designating it as Photopoint A. Eight monitoring photographs should be taken from Photopoint A with the camera on a tripod that is directly over the photomonitoring monument. The tripod should be adjusted to 152 cm (5 feet) above the ground. With the horizon positioned ¼ of the way down from the top of the frame, photographs should be taken to the west (photo Aa), northwest (photo Ab), north (photo Ac), northeast (photo Ad), east (photo Ae), southeast (photo Af), south (photo Ag), and southwest (photo Ah). Each photograph should be taken with a digital camera (dSLR or similar style), with the zoom lens set to a wide setting (18mm on a cropped-sensor dSLR camera).

BACK AT THE OFFICE

All data should be shared with the CDFW Native Plant Program so it can be saved in one place for future use and made publicly available via the California Natural Resources Agency Open Data Portal (https://data.cnra.ca.gov/). The Native Plant Program may also be contacted for access to data.

Type up a site visit summary to include information on the sites that were visited, activities conducted, issues, observations, and management recommendations.

GIS data should be uploaded for comparison with previously collected GIS data to evaluate trends in area occupied and changes in distribution. Change the file names for the monitoring photos using the following naming convention: [uppercase letter of macroplot][lowercase letter of the photopoint][YYYYMMDD]. For example, if a photo is taken at photopoint Ab, on August 10, 2022 the file should be named "Ab20220810". With the monitoring photos renamed, use a photo previewer program and the left and right arrow keys on the keyboard to compare monitoring photos with those taken during previous site visits and look for signs of disturbance, change, and other minor differences.

Compare results with the results from previous years. Think about any changes that would be beneficial to the species. Talk to the reserve manager about the management of the site. **This is the most important part of adaptive management!**

Summary of Results (2018-2023)

CDFW staff visited two or more CDFW lands annually between 2018 and 2023 for the purposes of monitoring Suisun thistle (Table 2).

Table 2. Dates of Monitoring

Year	Days	Monitoring Locations Visited
2018	August 16, 17, 22, 23	Peytonia Slough, Joice Island, Hill Slough
2019	August 5, 20	Peytonia Slough, Joice Island, Hill Slough
2020	July 27, August 18	Joice Island, Hill Slough
2021	August 9, 10, 13	Peytonia Slough, Joice Island, Hill Slough
2022	August 18, 22	Peytonia Slough, Joice Island, Hill Slough
2023	August 16, 18	Peytonia Slough, Joice Island, Hill Slough

A summary of the following information is summarized in this section:

- Distribution and abundance of Suisun thistle on CDFW lands
- Observed impacts to Suisun thistle populations
- Monitoring photographs
- Aerial surveys and mapping via drones
- Other observations

Monitoring photos and monitoring data associated with this document are available via the CNRA data portal at the following location: https://data.cnra.ca.gov/dataset/suisun-thistle-cirsium-hydrophilum-var-hydrophilum-abundance-solano-county-2018-2023. Suisun thistle distribution GIS

layers are available for use with permission from the Native Plant Program and have been submitted to the California Natural Diversity Database to update the distribution and population size of each occurrence.

JOICE ISLAND MONITORING LOCATION

Suisun thistle was present at the Joice Island Monitoring Location every year from 2018 through 2023 and abundance is presented in Figure 5. Across all monitoring years, average abundance was 464 plants, with an average of 176 in the reproductive life history stage, which is the highest abundance of the three monitoring locations. Our abundance estimates include a small number of reproductive plants (18 in 2022 and 12 in 2023) outside of CDFW lands on Rush Ranch Open Space that were observed from a distance, across a tidal channel. Suisun thistle has a patchy distribution at the Joice Island Monitoring Location but if a convex boundary is traced around the known locations that includes all the tidal marsh in between points (i.e. convex hull area), it is approximately 10 hectares (25 acres). Within this area, six different patches of Suisun thistle are separated from each other by at least 30 meters (98 feet). The convex hull area of each of these individual patches added together is approximately 1.1 hectares (2.7 acres), which is the smallest area of the three monitoring locations. This location therefore has the highest abundance and density of Suisun thistle plants among the three monitoring locations.

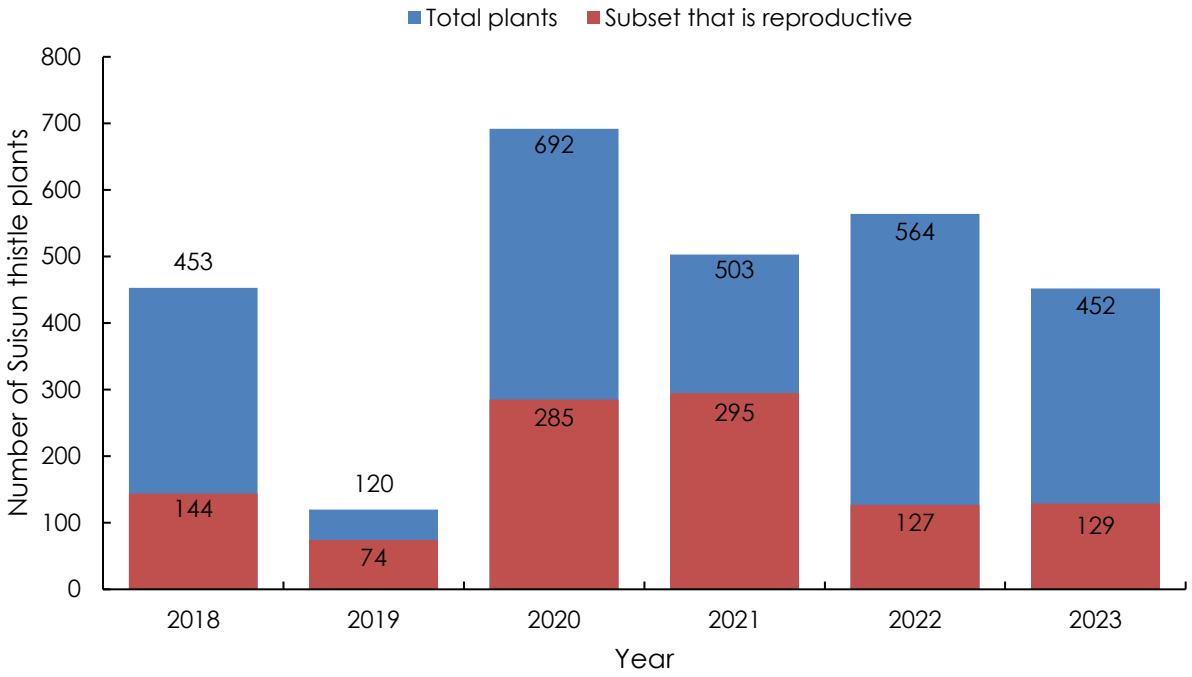

Figure 5. Number of Suisun thistle plants observed during surveys of the Joice Island Monitoring Location, 2018-2023, data collected in July or August.

Monitoring photos were taken at the Joice Island Monitoring Location. Suisun thistle is only clearly visible in monitoring photos taken in 2018 and 2020, particularly in photos Aa and Ab. All monitoring photos from 2018-2023 show little change in dominant vegetation composition and abundance, and no obvious habitat disturbances.

Surveys were primarily conducted on foot, and all Suisun thistle plants encountered were mapped. In 2019, CDFW used a DJI Phantom 4 Pro drone at an elevation of approximately 61 meters (200 feet) creating an orthomosaic image with a resolution of 0.6-inches for portions of the Joice Island Monitoring Location. In 2020, CDFW captured additional aerial imagery of a smaller portion of the Joice Island Monitoring Location, but at a lower altitude of 19 meters (62 feet), resulting in orthomosaic imagery with a resolution of 0.2 inches, which was high enough resolution to discern Suisun thistle from the surrounding vegetation. The area of drone imagery coverage at the Joice Island Monitoring Location is illustrated in Figure 6. In the small areas that are known to support Suisun Marsh thistle, it is possible to discern Suisun thistle from the surrounding vegetation based only on color in the 2019 0.6-inch resolution aerial imagery; however, that same gray color is present elsewhere in the image where Suisun thistle is known to not present, so this level of resolution is not adequate for detecting Suisun thistle in new areas (Figure 6, top). It is easier to discern Suisun thistle plants using the 2020 0.2-inch resolution aerial imagery of the same area, where both color and texture/pattern are more distinctive (Figure 6, bottom). At 0.2-inch resolution the plants appear as pinkish-grey with a spreading, dotty, foliage pattern. These images were taken towards the end of the season when Suisun thistle plants were completing their life cycles. Therefore, the foliage was fading to gray, which provided an effective contrast with the green vegetation from other plants in the marsh.

In 2020, a grassland wildfire burned right up to the transition between upland annual grassland and marsh, stopping just a few meters from the Joice Island Monitoring Location.

Figure 6. Sample of aerial imagery of Suisun thistle plants at the Joice Island Monitoring Location in 2019 at a resolution of 0.6-inch (top), and in 2020 at a resolution of 0.2-inch (bottom). Black circles highlight areas with Suisun thistle plants.

PEYTONIA SLOUGH MONITORING LOCATION

Prior to the 2018 CDFW site visits, the population at Peytonia Slough had no recorded observations since 1996. CDFW surveyed portions of Peytonia Slough Ecological Reserve for Suisun thistle on foot and via kayak in 2018 but the population was not found in the areas searched. In 2019, CDFW utilized a DJI Matrice 210 drone to survey for Suisun thistle, resulting in orthomosaic aerial imagery at a resolution of 0.6-inches for portions of Peytonia Slough Ecological Reserve (see Figure 3). Upon careful examination by hand, Suisun thistle was not found within the aerial imagery captured in 2019. The imagery collected was not quite of high enough resolution to definitively discern possible Suisun thistle plants that could be targeted for later surveys.

In 2021, CDFW rediscovered the Suisun thistle population in an area that was not surveyed in 2018 or 2019. CDFW staff accessed the population via kayak and boat, then on foot mapped 316 Suisun thistle plants, with 82 of them in the reproductive life history stage (e.g., bolting, flowering, fruiting). While reproductive plants are generally easy to see if the surveyor is in the immediate vicinity of them, plants in the basal rosette life history stage are far more difficult to detect due to the density of other marsh vegetation. There were, therefore, almost certainly Suisun thistle plants in the basal rosette life history stage that were present but that were not detected. The Suisun thistle plants were outside of the Peytonia Slough Ecological Reserve boundary, on CDFW lands designated as Peytonia Slough Conservation Easement. In 2022, CDFW staff again accessed the area via kayak and surveyed areas adjacent to where Suisun thistle was found in 2021 and mapped an additional 61 plants, with 42 of them in the reproductive life history stage. Because the areas surveyed in 2021 and 2022 did not overlap, these values should not be compared to each other, and it is more appropriate to consider them cumulatively as a rough estimate of overall population abundance. CDFW staff accessed the area again via kayak and surveyed another non-overlapping area in 2023 but no additional Suisun thistle plants were found. Although the abundance of short-lived plants like Suisun thistle experiences annual variation, based on our surveys in 2021 and 2022, the abundance of the Peytonia Slough population may hover around 400 plants. This suggests that the Peytonia Slough population is more abundant than the Hill Slough population, but less abundant than the Joice Island Monitoring Location. The Peytonia Slough population has a patchy distribution, but if a boundary is traced around the known locations that includes all the tidal marsh in between points (i.e. convex hull area), the total area contained by this boundary is approximately 13 hectares (33 acres), which is the largest convex hull of the three monitoring locations. Within this area, there are seven patches and three individuals that are separated from each other by at least 30 meters

(98 feet). The convex hull area of each of the seven patches and three individuals added together is approximately 0.5 hectares (1.2 acres).

On February 11 and 12, 2023, a wildfire burned portions of Peytonia Slough Ecological Reserve, removing aboveground portions of marsh vegetation in affected areas. When CDFW staff visited the Peytonia Slough population in August 2023, there was no evidence that fire had affected the area in and around the Suisun thistle population. The wildfire likely only burned the northern portion of Peytonia Slough Ecological Reserve and did not impact Suisun thistle.

Hill Slough Monitoring Location

Suisun thistle was present at the Hill Slough Monitoring Location every year from 2018 through 2023, but only one plant was observed in 2021(Figure 7). Across all monitoring years, average abundance was 100 plants, with an average of 43 plants in the reproductive life history stage, which is the lowest plant abundance among the three monitoring locations. The Hill Slough population is within a total convex hull area of approximately 2.5 hectares (6.2 acres), which is the smallest convex hull of the three monitoring areas. Within this area three different patches of Suisun thistle that are separated from each other by at least 30 meters (98 feet) have been mapped. The convex hull area of each of these individual patches added together is approximately 1.6 hectares (3.9 acres), which is the largest area occupied by Suisun thistle of the three monitoring locations. This location therefore has the lowest abundance and density of Suisun thistle plants among the three monitoring locations. The Hill Slough population is bisected by the upper reach of an impassible tidal channel of Hill Slough. Most of the Suisun thistle plants are on the north side of the channel, and a small number of plants have been observed on the south side of the channel.

Surveys were conducted annually on foot, and all Suisun thistle plants encountered were mapped in this manner. CDFW attempted to capture aerial drone imagery of the Hill Slough Monitoring Location in 2020. For technical reasons, CDFW was not able to process this imagery to generate a useable orthomosaic image.

In 2021, CDFW staff observed that the Hill Slough population was significantly impacted by trespass cattle grazing due to downed fencing. Cattle entered the Hill Slough Wildlife Area and grazed nearly all vegetation north of the impassible tidal channel to no higher than a few centimeters above ground-level. This impact was first reported to CDFW by Dr. Michael Vasey on June 4, 2021. The vegetation near the channels in this area had been very dense from 2018-2020, and the trespass grazing resulted in an enormous loss of vegetation biomass in the area. CDFW staff found only one surviving Suisun thistle plant at the Hill

Slough population in 2021, and the rosette only had five leaves, with two of them partially eaten. A barbed-wire fence separates Hill Slough Wildlife Area to the south from the property to the north where the cattle entered from. The barbed-wire fence runs in an east-west direction, and it is very dilapidated with rotten wooden and rusted metal posts due to the high salinity of the soil. The fence was pushed over in several locations, likely sometime between fall 2020 and June 2021. A narrow tidal channel that runs parallel to the fence also separates the two properties, but this channel only prevents cattle passage in the places where the channel is deep further to the west. There were five obvious locations along the fence where cattle from the property to the north were able to access the Hill Slough population in 2021.

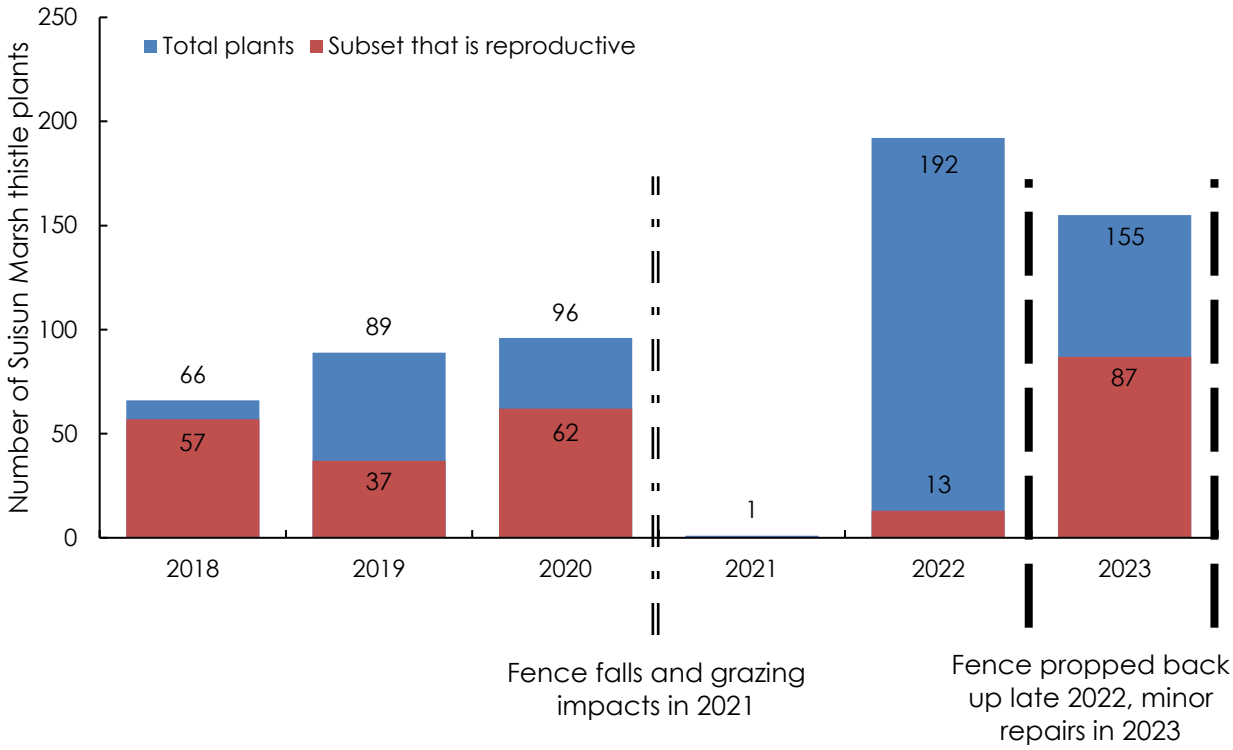

Figure 7. Number of Suisun thistle plants observed during late-summer surveys of the Hill Slough Monitoring Location.

This trespass grazing was reported to the CDFW land manager in 2021, but the fence remained down a year later at the time of the August 2022 data collection site visit. Nothing was in place to stop the cattle on the adjacent property from re-entering CDFW land. CDFW observed evidence of continued cattle grazing within Hill Slough Wildlife Area in 2022, including fresh cow pats, grazed vegetation, and trampling. Despite ongoing impacts, there were many basal rosettes of Suisun Marsh thistle north of the channel in 2022, but no reproductive individuals were found within this impacted area (Figure 8), which was expected since almost no rosettes were found post-grazing the prior

season. By contrast, the south portion of the Hill Slough population, which was inaccessible to the cattle, had 13 reproductive individuals (Figure 8). North of the channel, despite continued breaches to the fence, the grazing pressure was lower in 2022 and the vegetation partially rebounded from 2021 levels (Figure 9), but did not reach the levels of biomass that were observed in 2018-2020 prior to the trespass grazing. The rebound may have occurred because, once grazed, this area became similarly appealing to the cattle when compared to the surrounding pasture, and they were less motivated to enter Hill Slough Wildlife Area.

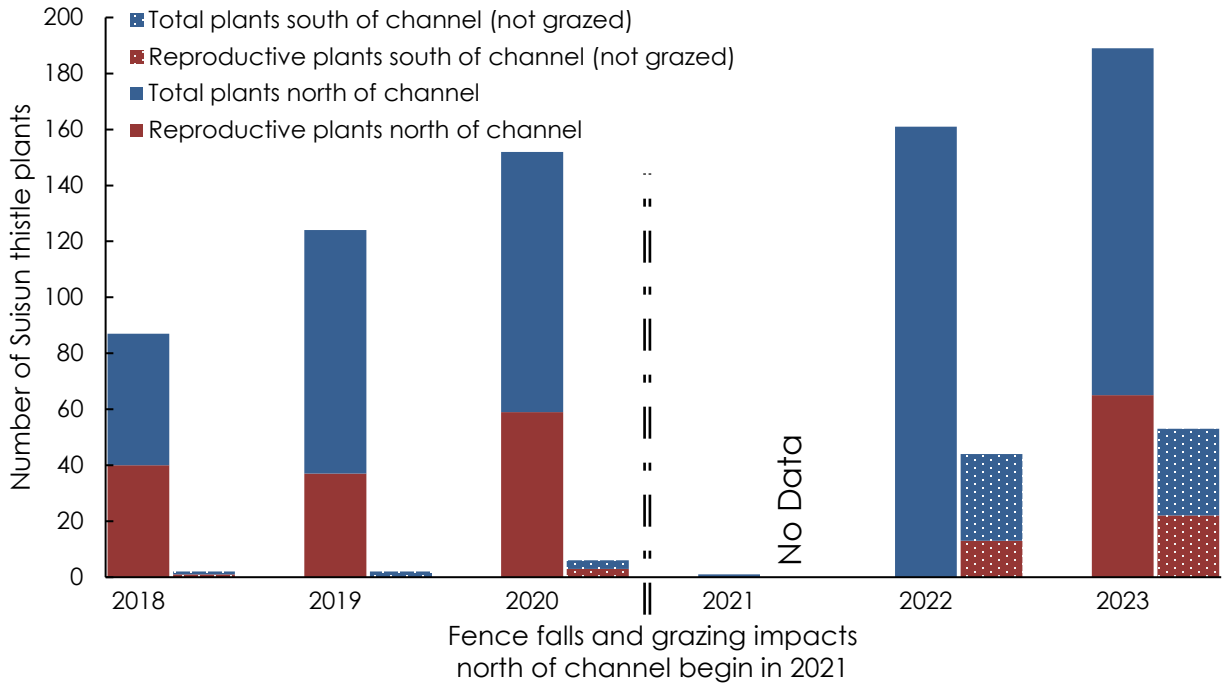

Figure 8. Number of Suisun thistle plants observed during surveys of the Hill Slough Monitoring Location, 2018-2023, data collected in July or August. Plants north of channel were affected by grazing impacts from 2021-2023 and plants south of channel were not affected. No data collected south of channel in 2021.

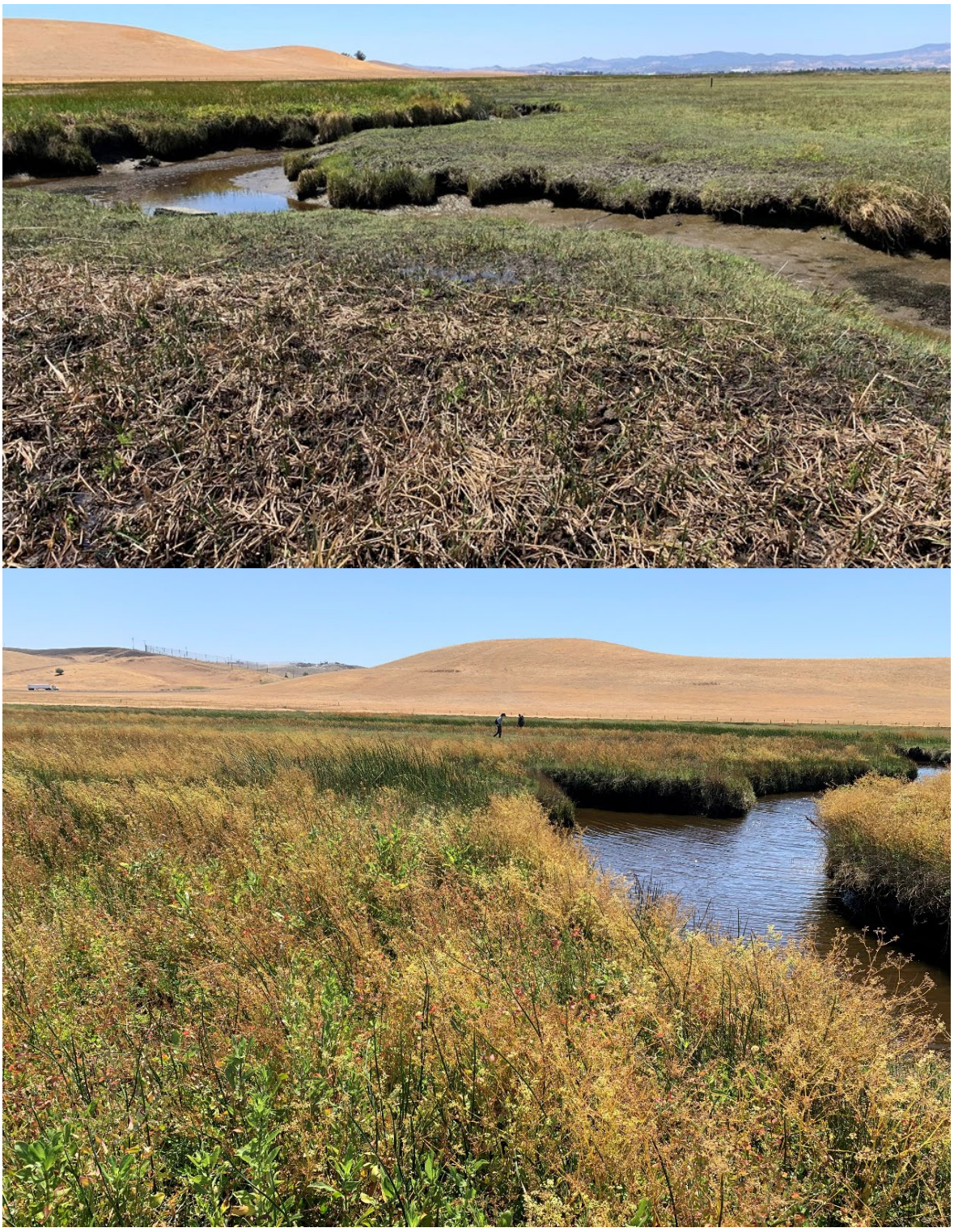

Figure 9. Vegetation at Hill Slough Monitoring Location for Suisun thistle in 2021 after grazing impacts (top), and in the same general area in 2022 after partial regeneration (bottom).

On November 3, 2022, staff from the CDFW Bay Delta Region repaired portions of the dilapidated fence in an effort to prevent further trespass grazing. Nevertheless, during the August 2023 data collection site visit, the fence was down again in one place and there were approximately 10 cows trespass grazing at the Hill Slough Monitoring Location again. CDFW staff chased the cows out of the area, propped the fence back up, and attempted to repair the fence with multitool pliers. There were more reproductive Suisun thistle plants at the Hill Slough population in 2023 than in any other monitoring year. The north side of the channel had 43 reproductive plants in the area that had been subjected to grazing, the south side of the channel had 22 reproductive plants. An additional 22 were found in a narrow area on the north side of the channel in an area that was protected from grazing via a ditch on one side and fencing on another. No Suisun thistle plants had previously been mapped in this narrow area, and although it was not directly impacted from grazing, grazing occurred on the vegetation adjacent to it. In January 2024, the new landowner adjacent to the Hill Slough Monitoring Location (Solano County Water Agency) terminated the cattle grazing lease due to the repeated trespass. The landowner proposes sheep and goat grazing twice per year for fire suppression only.

Discussion and Interpretation of Results

CDFW is responsible for managing all or a significant portion of the remaining three Suisun thistle populations, and therefore has a uniquely important responsibility to ensure the continued existence of the species. CDFW must keep in mind both the maintenance and enhancement of the existing populations as well as the genetic health of the populations. CDFW lands support three of the four genetic populations of Suisun thistle. Due to the ongoing threats to the species, these three genetic populations of Suisun thistle are incredibly important to conserve to maintain what little genetic variation there is.

Suisun thistle competes with neighboring vegetation for light, but the density of vegetation is often very high. Disturbances which allow more light to reach the ground may provide an increased chance of germination and survival of Suisun thistle seedlings (Graham-Bruno et al. 2023). Ditching for mosquito abatement is noted to have likely expanded the Suisun thistle's geographic distribution in the past by providing additional habitat along the edges that meets the light and soil salinity requirements for the species. CDFW monitoring data from the Hill Slough population following extreme grazing impacts in 2021 are consistent with the hypothesis that disturbance can stimulate germination and perhaps also increase the size of Suisun thistle populations. Experimental manipulation to reduce vegetation density in Suisun thistle habitat at appropriate times of the year could help increase Suisun thistle abundance in treated areas.

While periodic and controlled disturbance may have positive effects for Suisun thistle, repeated and ongoing disturbance, such as continuous grazing, is almost certainly a negative impact and could extirpate the species if impacts are allowed to persist. Reproductive Suisun thistle has only been mapped in habitats that appeared to have minimal disturbance during our surveys. No reproductive plants have been seen across a tidal channel just west of the Hill Slough population that appears to contain suitable habitat except that it has experienced unrestricted cattle grazing for the duration of the 2018-2023 monitoring period. It is possible that areas such as this could be suitable for the species if cattle grazing were restricted. The Hill Slough population is the most imperiled population of Suisun thistle and protection of this population should be a top conservation priority for CDFW.

The biennial or short-term perennial life cycle of Suisun thistle makes it especially vulnerable to repeated disturbances since the plants require two or more years to reach maturity and produce seeds. In 2021, when cattle grazed nearly every plant that was a first-year rosette and every plant that was a second-year reproductive individual, it guaranteed that there would be no seeds added to the seed bank in 2021, as well as in 2022, since it takes this species at least two years to reach maturity. In a natural setting, the species has two or more cohorts that alternate, with one group generally germinating in odd years and reproducing in even years, and the other group generally germinating in even years and reproducing in odd years. Each cohort may be maintaining slightly different genetic diversity. The removal of both cohorts at once resets the cycle beginning in 2022 with mass germination, followed by a smaller, and potentially less diverse, cohort in 2023. The effects of trespass grazing in that single year may be felt by the population for a long time or perhaps permanently. If grazing pressure had continued to be just as intense the second season, or if intense grazing had occurred again in 2023 in the second year of life for that 2022 cohort, the result would have been the effective flushing of the seed bank and accelerated extirpation of this population. The removal of an entire age class of Suisun thistle in 2021 from trespass grazing potentially removed a significant amount of genetic diversity from the population and may explain the finding that individuals sampled from the Hill Slough population after these grazing impacts have much less genetic variation than any other population (Cantly 2023).

Due to the size of Suisun Marsh and logistical challenges with conducting comprehensive surveys for the species, it is possible that there are additional undiscovered populations of Suisun thistle. These populations could be a critical source of genetic diversity for the species, and searching for them should be a conservation priority.

Assessment of the Monitoring Project

The project has resulted in a better understanding of the current status and trends of Suisun thistle populations on CDFW lands. Important contributions include documenting and attempting to halt further trespass grazing that caused significant impacts to the Hill Slough population, and rediscovering the Peytonia Slough population which was last seen in the 1990s. Rediscovery of the Peytonia Slough population also allowed it to be included in the population genetics analysis by Cantly (2023). Our use of drones to survey, map, and monitor Suisun thistle was not as fruitful as hoped so was not included in the monitoring protocol. In time, technology may improve enough to overcome some of the logistical and technological challenges encountered, including tradeoffs between area covered and the resolution of imagery captured, limitations in drone battery life, and issues encountered while processing imagery from low-elevation flights into an orthomosaic. Through mapping the distribution of this species, CDFW documented areas where plants are consistently present from year to year, and others where plant presence fluctuates between years. The photomonitoring point was established at an accessible location adjacent to an area with abundant plants in 2018; however, plants were only clearly visible again from this photomonitoring point in 2020. A short distance from this photomonitoring point is an area where plants have been present every year, and this area may be a better representation of annual fluctuations at the Joice Island Monitoring Location.

Management Recommendations

Management objectives and management implications for Suisun thistle on CDFW lands are provided below, with a discussion of whether the management implications should be triggered based on the monitoring results. Additional management recommendations for the project are also included.

Management Objective #1

Maintain populations of at least 100 Suisun thistle plants at CDFW's Peytonia Slough Ecological Reserve, at least 100 Suisun thistle plants at Grizzly Island Wildlife Area Joice Island Unit, and at least 50 Suisun thistle plants at Hill Slough Wildlife Area during any monitoring year. These plants may be in any life history stage (basal rosette or reproductive).

Management Implication #1: If fewer than the target number of Suisun thistle plants are found at Peytonia Slough Ecological Reserve, Grizzly Island Wildlife Area Joice Island Unit, or Hill Slough Wildlife Area during any monitoring year, and the reason for the number of plants observed is not vegetation disturbance or another impact that can be clearly remediated, implement a vegetation

disturbance experiment on that property in an area where plants have previously been mapped. The objective of the vegetation disturbance shall be to facilitate Suisun thistle seed germination and recruitment. Disturbance treatments could be implemented via hand tools or, if appropriate, via animals or motorized equipment. Suisun thistle seeds have been reported to germinate as early as September, so it may be appropriate to implement vegetation disturbance sometime between late August and late September.

Recommendation: Management implication #1 has not been triggered.

OTHER RECOMMENDATIONS

- CDFW's Bay Delta Region or Native Plant Program should monitor Suisun thistle populations on CDFW lands using the monitoring protocol described in this document. Monitoring the Hill Slough population is a top conservation priority.
- Replace fencing at the Hill Slough population to ensure that trespass grazing is less likely to occur in the future. Monitor the fencing regularly during the growing season to ensure any breach in the fencing is repaired immediately.
- Establish additional photomonitoring points, particularly at the Hill Slough Monitoring Location and at the Joice Island Monitoring Location where plants have been present every year.
- As a hedge against extinction, collect and store seeds from all Suisun thistle populations on CDFW lands in a conservation seed bank following protocols for collecting seed from rare plant species. Consider including collections for research to assess any benefits of inter-populational hybrid crosses (Cantly 2023).
- In light of the species' low abundance and ongoing threats, consider submitting a petition to list Suisun thistle under the California Endangered Species Act.

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